STUDIES ON WESTERN AUSTRALIAN PERMIAN BRACHIOPODS 12. ADDITIONS TO THE LATE ASSELIAN–TASTUBIAN FAUNAS

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New species and records of Early Permian (Asselian–Tastubian) brachiopods from the Lyons Group and Carrandibby Formation of the Carnarvon Basin, and the Grant Group of the Canning Basin, that are important for the geology and stratigraphy including the biostratigraphy of the Early Permian of Western Australia, are described and illustrated. New taxa described are *Neochonetes (Sommeriella) obrieni* sp. nov., *Etherilosia carolynae* sp. nov., *Etherilosia calytrixi* sp. nov. and *Rhynchopora australasica* sp. nov. The age of the earliest Permian faunas of Western Australia is briefly discussed with the conclusion that they possibly range in age from Asselian to Late Tastubian.

BRACHIOPODS are abundant throughout the Permian-marine sequences of the Perth, Carnarvon and Canning Basins of Western Australia, where they are valuable for zonation purposes and inter-basinal correlation (Archbold 1993a; Archbold et al. 1993). Despite numerous recent studies on the brachiopod faunas having been published (e.g. Archbold 1993b), the earliest Permian (Asselian–Tastubian) faunas of Western Australia remain only partially described. The present study brings together new collections and specimens from the Grant Group of the Canning Basin and the Lyons Group and Carrandibby Formation of the Carnarvon Basin and revises material from the subsurface Grant Group previously partially described by Waterhouse (in Foster & Waterhouse 1988).

References to the Permian stratigraphy of the Carnarvon and Canning Basins are provided in previous parts of this series although recent work is indicated in this study as are additional remarks on the age and correlation of pertinent faunas. Specific locality and stratigraphical data are also provided below.

All illustrated material is deposited in either the collections of the Geological Survey of Western Australia, Perth (GSWA F) or the Commonwealth Palaeontological Collection (CPC) of the Australian Geological Survey Organisation, Canberra (AGSO).

All illustrated specimens of new species, other than holotypes, are paratypes.

STRATIGRAPHY, LOCALITIES AND AGE

Canning Basin

A small brachiopod assemblage from the Wye Worry Member of the Carolyn Formation, Grant Group (see Crowe & Towner 1981), discovered by geologists of the Australian Geological Survey Organisation, was sent to the present author for study by Dr P. E. O'Brien. Previously discovered marine fossils from this unit were mollusean dominated (Dickins et al. 1978). The present assemblage, consisting of *Neochonetes (Sommeriella) obrieni* sp. nov., *Etherilosia carolynae* sp. nov., *Costatumulus* sp. *Trigonotreta* sp. and fragments of *Deltopecten* sp. was discovered on the Noonkanbah 1:250 000 map sheet (Crowe & Towner 1981) at latitude 18°42′48″S and longitude 124° 54′48″E, east of Mount Tuckfield and east of the Carolyn Bore. A stratigraphical section of the locality after a sketch section provided by Dr O'Brien, is given in Fig. 1. The correlation of these assemblages from the Wye Worry Member is most likely with the faunas of the Upper Lyons Group and Carrandibby Formation of the Carnarvon Basin (Archbold 1993a), an interpretation strengthened by the discovery of a specimen of *Neochonetes (Sommeriella) obrieni* sp. nov. from the Carrandibby Formation (see below).

The brachiopod assemblage described by Waterhouse (in Foster & Waterhouse 1988) from an isolated subsurface section within the Grant Group on the Barbwire Terrace is revised and fully

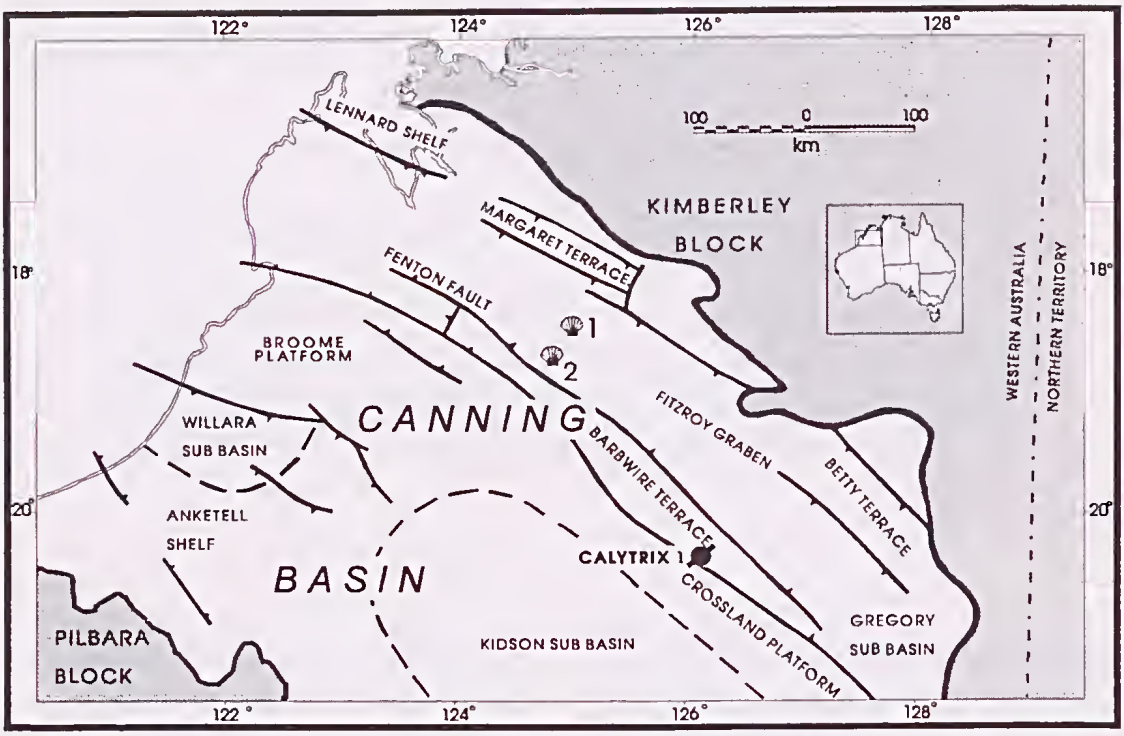


Fig. 1. Locality map of Grant Group marine fossil localities. 1 = Dickins et al. (1978) locality. 2 = new faunal locality described herein.

illustrated in this study. Details of the stratigraphy of the core section are provided by Foster & Waterhouse (1988) and comprehensive sedimentological data is provided by Redfern (1991) who defined three subsurface formations being in ascending order the Hoya, Calytrix and Clianthus formations. The marine fossils described by Waterhouse (in Foster & Waterhouse 1988) are from the Calytrix Formation. Redfern & Millward (1994) concluded that the Barbwire Terrace Formations represented only the upper part of the Grant Group, a view shown by Jones & Young (1993: 15) who correlated the Calytrix Formation with the Wye Worry Member of the Carolyn Formation.

Briggs (1991: 34) initially correlated the upper Grant Group (Carolyn Formation) with the Callytharra Formation of the Carnarvon Basin. He subsequently (1993: 52) correlated the Calytrix fauna with that of the underlying Carrandibby Formation, a view also indicated by Archbold (1993a), but Briggs preferred an early Tastubian age for the assemblage. Briggs (1993: 54) argued that the age of the Callytharra Formation was late Tastubian and that its age had 'been distorted by the correlation of earlier workers' by correlation with 'the younger (Sterlitamakian) Nura Nura Member (Canning Basin)'. While there is always scope for interpretation in correlating faunas, in this case the following points are noteworthy. *Metalegoceras* sp. nov. from the base of the Callytharra Formation is considered to be Sterlitamakian in age (Glenister et al. 1993: 292). Comparable metalegoceratids indicate correlation of the Nura Nura Member (Canning Basin), Callytharra Formation and Fossil Cliff Member (Perth Basin) and a Sterlitamakian age is indicated (Glenister et al. 1993: 56). Discussions on the age of *Svetlanoceras irwinense* are equivocal (cf. Briggs 1993: 54–55 and Glenister et al. 1993: 56). Data from brachiopods and other groups indicate significant faunal links between the Fossil Cliff Member, Callytharra Formation and the Nura Nura Member (and equivalent units) for correlation purposes (Thomas & Dickins 1954; Dickins 1963; Archbold 1988, 1990, 1993a) and hence a Sterlitamakian age is retained for these units in this study. As a result, the age of the Carrandibby Formation, immediately

underlying the Callytharra Formation and the Upper Grant Group are regarded as being late Tastubian in age as in Archbold (1993a).

The brachiopod assemblage from the Calytrix Formation includes the following forms as revised in this study: *?Streptorhynchus* spp., *Arctitreta* sp., *Neochonetes (Sommeriella) obrieni* sp. nov., *Etherilosia calytrixi* sp. nov., *Costatumulus capillatus* (Waterhouse), *?Cyrtella* sp., *Trigonotreta* sp., *?Martinia* sp. and *Spiriferellina* sp. The use of latex for making casts from natural moulds has been invaluable in elucidating details not described by Waterhouse (in Foster & Waterhouse 1988) and all forms are illustrated herein. The age of the assemblage is considered to be late Tastubian.

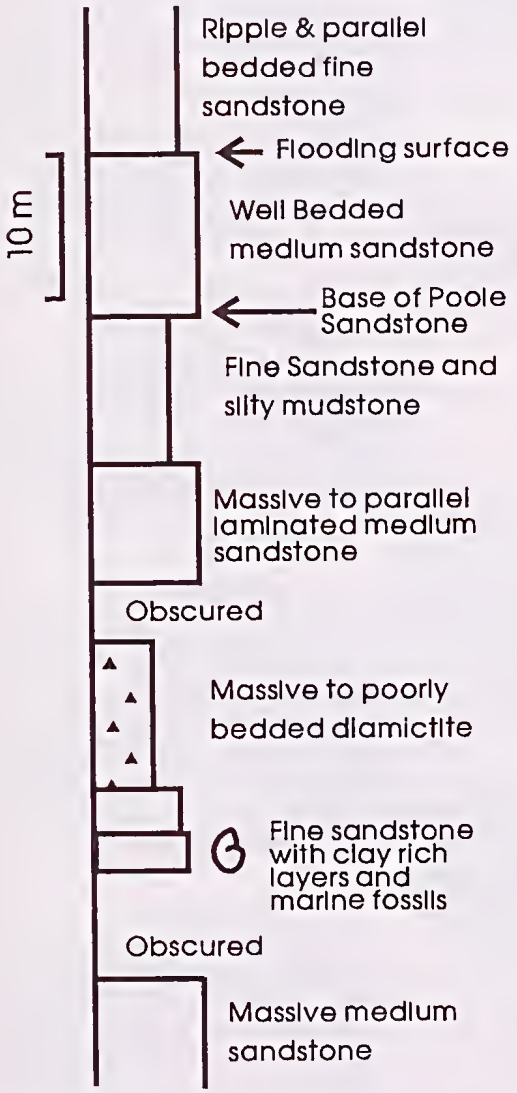


Fig. 2. Measured section cropping out east of Carolyn Bore (latitude 18°42′48″S; longitude 124°54′48″E) Noonkanbah 1:250 000 sheet.

Carnarvon Basin

Additional material is described from two outcrop localities within the Lyons Group and from the base of the Lyons Group and the Carrandibby Formation from the BMR 8, Mount Madeline Core (see Mercer 1967 for details of this well). Locality GSWA 30111, described as Lyons Group cropping out near Snake Well, Eudamullah Station, Carnarvon Basin has yielded, in addition to the *Linoproductus* sp. recorded by Archbold (1983, fig. 1A, 1B), incomplete specimens of *Taeniothaerus* sp., *?Callytharrella* sp. and *Spiriferella* sp. which are placed on record in this study. These specimens are the oldest record of these genera in the Western Australian Permian and may provide a record of a brief interglacial period during the glacially dominated Lyons Group period of sedimentation. The lithology of the samples is that of a silty fine sandstone with no shell material preserved and hence is unlike the preservation of fossils in the overlying Callytharra Formation.

From the stratigraphically lowest known marine locality in the Lyons Group (AGSO locality ML6, 5.6 km west of north of Moogooree Homestead), *Rhynchopora australasica* sp. nov. is described. Specimens are also described and figured from Core 32 of the Mount Madeline (BMR 8) well, Lyons Group, Carnarvon Basin from a depth of 2994–3004 feet (=912.5–915.5 metres) from Core 18 of the same well (depth 1665–1671 feet = 507.5–509.3 metres) a specimen of *Neochonetes (Sommeriella) obrieni* sp. nov. is recorded and illustrated. This core interval represents a limestone at the base of the Carrandibby Formation (Mercer 1967).

Rhynchopora australasica sp. nov. occurs low in the *Lyonia lyoni* Zone (Archbold 1993a) and is probably of Asselian age. Other faunal elements outlined above are of Late Tastubian age and appear to equate with the *Trigonotreta occidentalis* Zone (Archbold 1993a).

Palynological data

Foster (in Foster & Waterhouse 1988), on the basis of palynofloras retrieved from the Calytrix No. 1 bore core, established the *Granulatisporites confluens* Oppel-zone. This Oppel-zone, found throughout the three formations defined by

Redfern (1991), occurs stratigraphically below Stage 3a palynofloras which are themselves marked by the entry of *Pseudoreticulatispora pseudoreticulata,* as reviewed by Foster (in Burger et al. 1992). Backhouse (1991, 1993) has argued that the *Granulatisporites confluens* Oppel-zone represents the upper part of the underlying Stage 2 palynofloral unit. The present author would argue on the basis of the data from marine faunas and superpositional stratigraphy, that the *Granulatisporites confluens* Oppel-zone is of Tastubian age, ranging down into the Asselian.

SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA

Order STROPHOMENIDA Öpik, 1934

Suborder ORTHOTETIDINA Waagen, 1884

Superfamily ORTHOTETOIDEA Waagen, 1884

Family STREPTORHYNCHIDAE Stehli, 1954

Genus **Streptorhynchus** King, 1850

Type species. *Terebratulites pelargonatus* Schlotheim, 1816.

?Streptorhynchus spp.

Fig. 5A–B

Comments. Two illustrated specimens (GSWA F49444–49445) of dorsal valves indicate the presence of *Streptorhynchus* or an allied genus in the assemblage from the Calytrix Formation, Grant Group. A small external mould (GSWA F49444, maximum width 8.8 mm) possesses fine, bifurcating costellae (9 per 5 mm at anterior margin). An incomplete dorsal valve internal mould (GSWA F49445, estimated maximum width 25+ mm) possesses the characteristic dorsal cardinalia of *Streptorhynchus*. The specimens are inadequate for comparison with other Western Australian species.

Genus **Arctitreta** Whitfield, 1908

Type species. *Arctitreta pearyi* Whitfield, 1908.

Arctitreta sp.

Fig. 5C

Comments. A damaged dorsal valve from the Calytrix Formation, Grant Group, (GSWA F49446, maximum width 23 mm, length 24.5 mm, hinge width 19+ mm) strongly recalls *Arctitreta plicatilis* (Hosking 1932; see also Thomas 1958a and Archbold et al. 1993) from the Callytharra Formation, in details of valve size and costellae. The valve is thick-walled. The specimen represents the oldest occurrence of the genus from the marine Permian of Western Australia.

Order CHONETIDA Nalivkin, 1979

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETOIDEA Bronn, 1862

Family RUGOSOCHONETIDAE Muir-Wood, 1962

Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus **Neochonetes** Muir-Wood, 1962

Subgenus **Neochonetes (Sommeriella)** Archbold, 1982

Type Species. *Chonetes prattii* Davidson, 1859.

Neochonetes (Sommeriella) obrieni sp. nov.

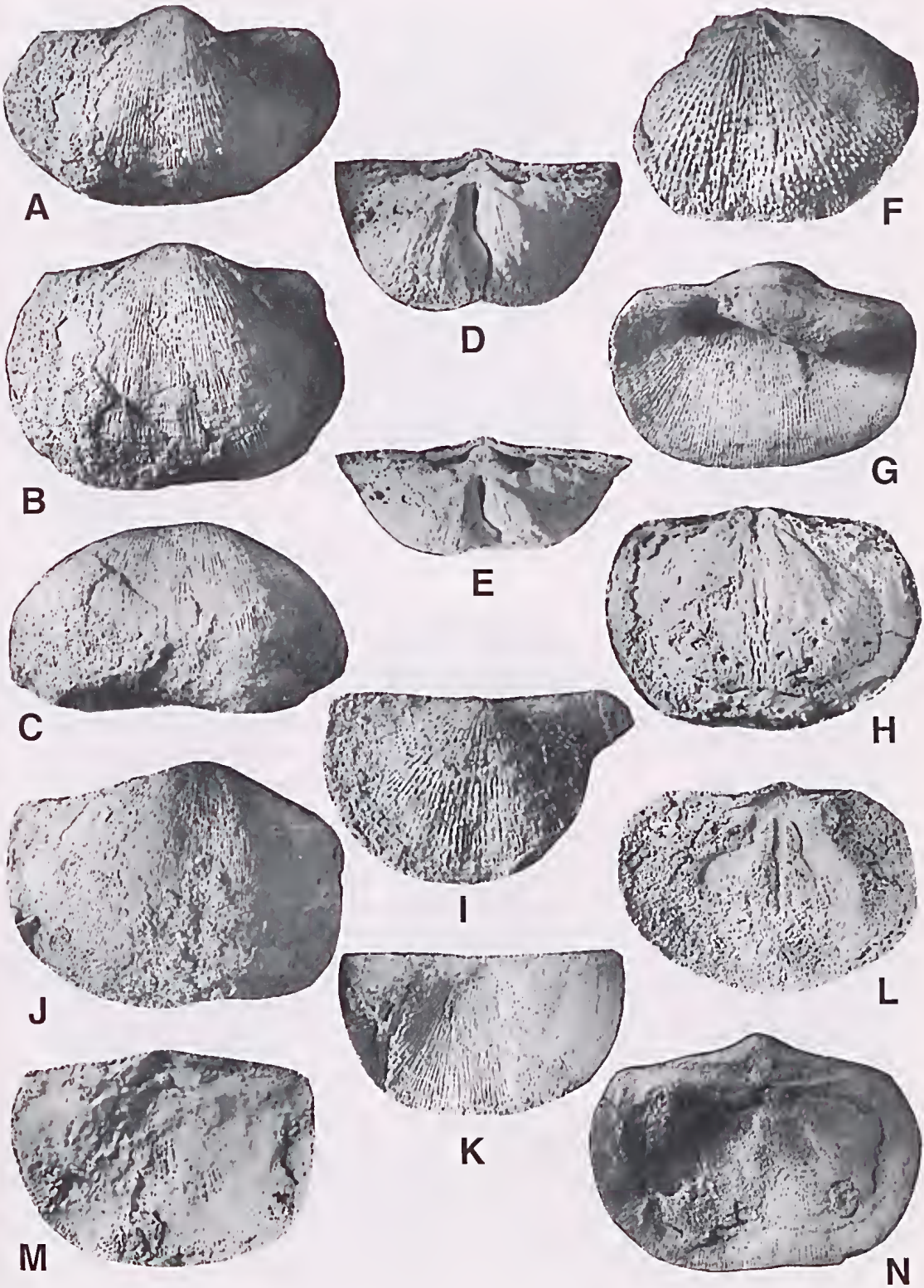
Figs 3A–N, 5D–I, 8B

Neochonetes (Sommeriella) aff. *pratti.*—Waterhouse (in Foster & Waterhouse) 1988: 155, fig. 7a, b.

Neochonetes (Sommeriella) aff. *prattii.*—Archbold & Dickins 1991: 4.

Neochonetes (Sommeriella) sp. nov..—Archbold 1993a: 314, 315.

Fig. 3. *Neochonetes (Sommeriella) obrieni* sp. nov. All specimens from Wye Worry Member, Carolyn Formation, Grant Group. A–C, Holotype, CPC 33501, ventral valve in postero-ventral, ventral and antero-ventral views, ×2.6. D, E, CPC 33502, ventral valve internal mould in postero-ventral and posterior views, ×2.5. F, CPC 33503, dorsal valve, interior view, ×2.5. G, CPC 33504, shell in dorsal view, ×2.6. H, CPC 33505, internal mould of ventral valve, ×2.5. I, CPC 33506, worn dorsal valve interior, ×3.8. J, CPC 33507, ventral valve in ventral view, ×2.5. K, CPC 33508, dorsal valve external view, ×2.5. L, CPC 33509, dorsal valve internal mould, ×2.5. M, CPC 33510, worn dorsal valve in dorsal view, ×2.5. N, CPC 33511, shell in dorsal view, ×2.6.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Etymology. For Dr Philip E. O'Brien.

Holotype. CPC 33501, a ventral valve (illustrated fig. 3A–C) from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group.

Other figure material. CPC 33512, a ventral valve from Mount Madeline 8 Bore Core, Carrandibby Formation, Carnarvon Basin. CPC 33502–33511, 1 ventral valve, 2 internal moulds of ventral valves, 5 dorsal valves and 2 shells from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group, Canning Basin GSWA F47187, a ventral valve, GSWA F47186, an external mould of the dorsal surface of a shell, GSWA F49447, a ventral valve external mould and GSWA F49448, a deeorticated ventral valve, all from the Calytrix Formation, Grant Group, Canning Basin.

Measurements (in mm). e = estimate.

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
CPC 33501	16.0	19.3	13.5	–
CPC 33512	11.8	13.5e	10.5	–
CPC 33502	16.8	17.0	–	–
CPC 33503	–	17.4e	–	11.8
CPC 33504	–	16.9	12.4	11.6
CPC 33505	16.6	19.6	13.8	–
CPC 33506	11.2	11.8e	–	7.6
CPC 33507	–	21.8	17.2	–
CPC 33508	17.0	17.4	–	10.4
CPC 33509	–	19.2	–	12.6
CPC 33510	15.0	15.6	–	10.1
CPC 33511	15.2	17.9	13.0	11.6
GSWA F47187	–	12.4	9.0	–
GSWA F47186	17.4	18.0e	10.2	8.6
GSWA F49447	–	12.0e	7.1	–
GSWA F49448	–	21.2e	15.0e	

Description. Small to medium sized *Neochonetes.* Convexity of ventral valve moderate with median flattening rather than distinct sulcus. Dorsal valve gently concave with no median fold. Greatest shell width at about mid-length of shell. Exterior shell surface with weakly developed growth lines and fine capillae (4 to 5 per mm at 10 mm from umbones) increasing in number by bifurcation. Ventral interarea low, dorsal interarea very low. Cardinal spines project at variable angle (30° to 50° on available material). Ventral umbo low, rounded.

Ventral interior with short, stout teeth. Median septum arises under delthyrium, thickened, about half valve length. Muscle scars strongly impressed. Diductor scars large, coarsely striated. Lateral and anterior margins strongly papillose.

Cardinal process low, poorly known. Chilidium unknown. Alveolus distinct. Median septum distinct, broad, approximately 60% of valve length. Brachial ridges distinct at maturity. Anterior of valve papillose. Submature interior with papillose radiating ridges.

Discussion. *N. (S.) obrieni* sp. nov. is a distinctive small to medium sized representative of the genus readily distinguished from other species by means of its lack of sulcus, smaller size and moderately convex ventral valve at maturity. *N. (S.) prattii* (Davidson) as revised by Archbold (1981d), *N. (S.) tenuicapillatus* Archbold (1981d) and *N. (S.) cockbaini* Archbold (in Archbold & Shi 1993) are all large species with distinct sulci of younger (Sterlitamakian–Artinskian) ages from Western Australia. The small *Neochonetes (S.) hockingi* Archbold (1991a) from the Aktastinian Wooramel Group, Carnarvon Basin, Western Australia possesses coarser capillae and a less convex ventral valve than *N. (S.) obrieni* sp. nov. *N. (S.) robustus* Archbold (1981d) from the early Baigendzhinian of Western Australia is a strongly convex species with a rounded outline at maturity.

Order PRODUCTIDA
Sarycheva & Sokolskaya, 1959

Suborder STROPHALOSIIDINA
Waterhouse, 1975

Superfamily STROPHALOSIOIDEA
Schuchert, 1913

Family STROPHALOSIIDAE Schuchert, 1913

Subfamily STROPHALOSIINAE
Schuchert, 1913

Genus Etherilosia Archbold, 1993

Type species. *Strophalosia etheridgei* Prendergast, 1943.

Comments. The distinctive spine arrangement of the ventral valve including rhizoid spines and the large cicatrix of attachment described for *Etherilosia* by Archbold (1993b) indicates that the genus is appropriately accorded full generic rank rather than a subgenus of *Heteralosia.*

Etherilosia carolynae sp. nov.

Fig. 4A–I

Heteralosia sp. nov. Archbold 1993a: 315.

Etymology. After the Carolyn Valley, Saint Georges Range, Canning Basin.

Holotype. CPC 33513, an external mould of a ventral valve, from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group.

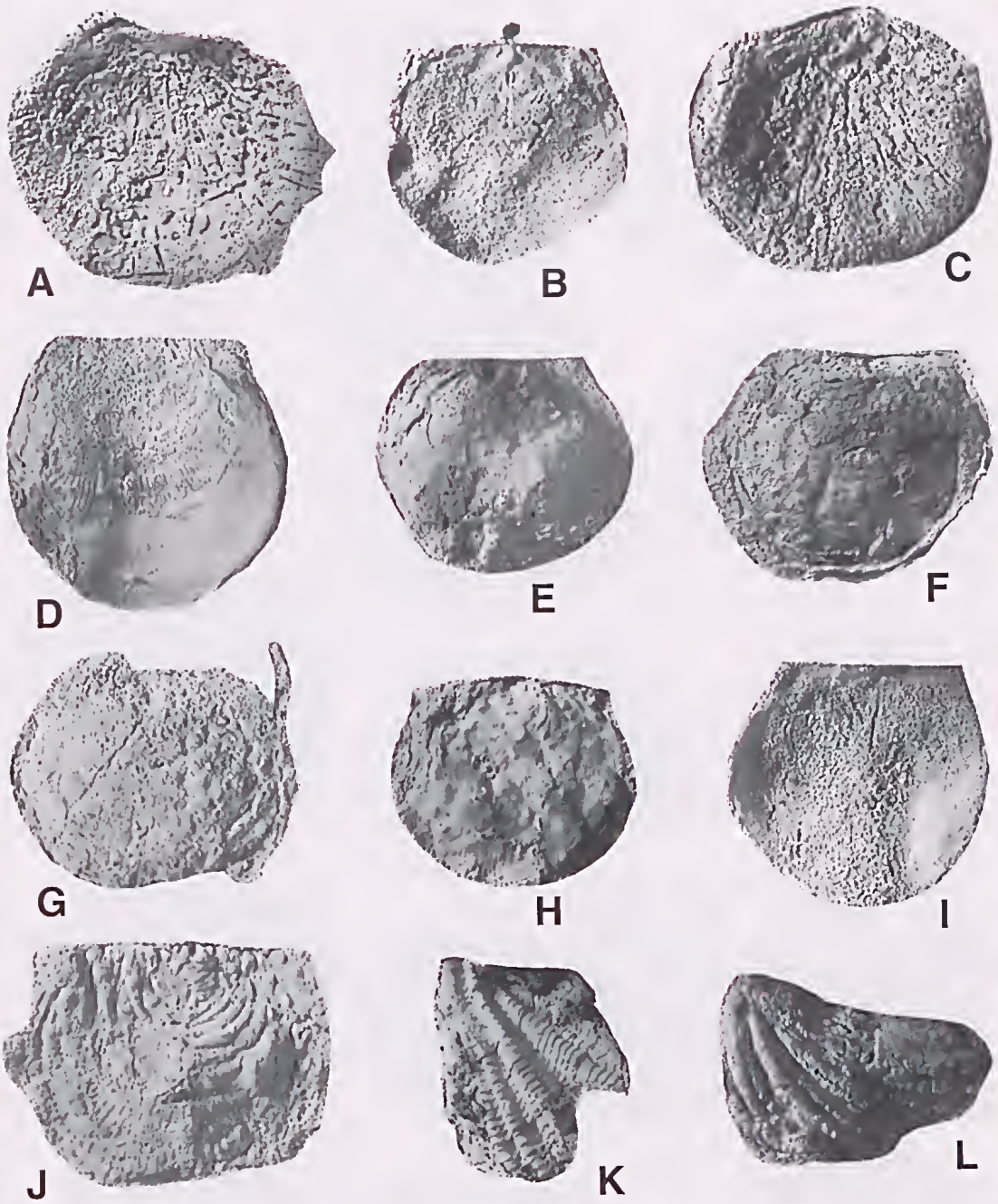


Fig. 4. All speeimens from Wye Worry Member, Carolyn Formation, Grant Group. A–1, *Etherilosia carolynae* sp. nov. A, holotype, CPC 33513, external mould of ventral valve, ×3. B, CPC 33514, dorsal valve internal mould, ×3. C, CPC 33515, ventral valve external mould, ×4. D, 1, CPC 33516, dorsal valve external mould, and internal mould, ×3.2. E, CPC 33517, worn dorsal valve, internal view, ×3. F, CPC 33518, dorsal valve external mould, ×3.2. G, CPC 33519, dorsal valve external mould with mould of ventral rhizoid spine, ×4.2. H, CPC 33520, worn dorsal valve, internal view, ×3.2. J, *Costatumulus* sp., CPC 33521, dorsal valve external mould, ×5.5. K, L, *Trigonotreta* sp. K, CPC 33522, incomplete ventral valve exterior, ×3.5. L, CPC 33523, incomplete ventral valve exterior, ×2.5.

Other figured material. CPC 33514–33520, 1 ventral valve external mould, 2 dorsal valve internal moulds, 5 dorsal valve external moulds all from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group.

Measurements (in mm). e = estimate.

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
CPC 33513	–	15.0	13.8	–
CPC 33514	9.0	11.5	–	10.5
CPC 33515	7.4	9.0	8.8	7.8
CPC 33516	9.6	12.2	–	11.8
CPC 33517	9.0	12.1	–	10.4
CPC 33519	5.4	8.0	–	6.2
CPC 33520	7.2e	10.2e	–	9.6

Description. Shell medium sized for genus, subcircular to transverse in outline. Hinge extremities finely pointed at maturity. Ears small, variably developed. Ventral valve moderately convex. Cicatrix poorly known but of moderate size. Ventral valve spinose with spines in poorly developed concentric rows, adherent posterior, suberect anteriorly at maturity. Spines spaced at 1 to 2 mm intervals, individual spines from 0.3 mm to 0.5 mm thick. Rhizoid spines apparently present as indicated by CPC 33519.

Interareas distinct, flat, relatively low. Delthyrium small, pseudodeltidium unknown.

Dorsal valve flat during early ontogeny, concave anteriorly, weakly developed geniculation in front of visceral disc. Concentric lamellae distinct, fine capillae prominent (3 to 4 per mm). Spines absent.

Ventral interior unknown. Cardinal process spike-like, interior face bilobed. Sockets small, moderately deep. Median septum thin, blade-like, approximately one-third valve length. Muscle scars and brachial ridges poorly developed.

Discussion. Finer ventral spines, lower ventral convexity, larger size at maturity and strongly developed capillae at submaturity and maturity distinguish the new species from *Etherilosia etheridgei* (Prendergast 1943), see Archbold (1986, fig. 3A–Z, AA–BB). *Etherilosia prendergastae* (Coleman 1957) as revised by Archbold (1986, 1993b), is of comparable size to *Etherilosia carolynae* sp. nov. and possesses relatively fine ventral spines but shows greater concavo-convexity. *Etherilosia calytrixi* sp. nov., as presently understood, is a smaller species with only a trace of fine capillae developed at the extreme anterior of the dorsal valve.

Etherilosia calytrixi sp. nov.

Fig. 5J–Q

Strophalosia cf. *subcircularis*—Waterhouse (in Foster & Waterhouse) 1988: 155, figs 7e, 8a–c.
small *Strophalosia* (partim)—Waterhouse 1989: 367.
Strophalosia cf. *irwinensis*—Archbold (in Archbold & Dickins) 1991: 4.
cf. *Strophalosia concentrica*—Briggs 1993: 52.
Heteralosia sp. nov. Archbold 1993a: 315.

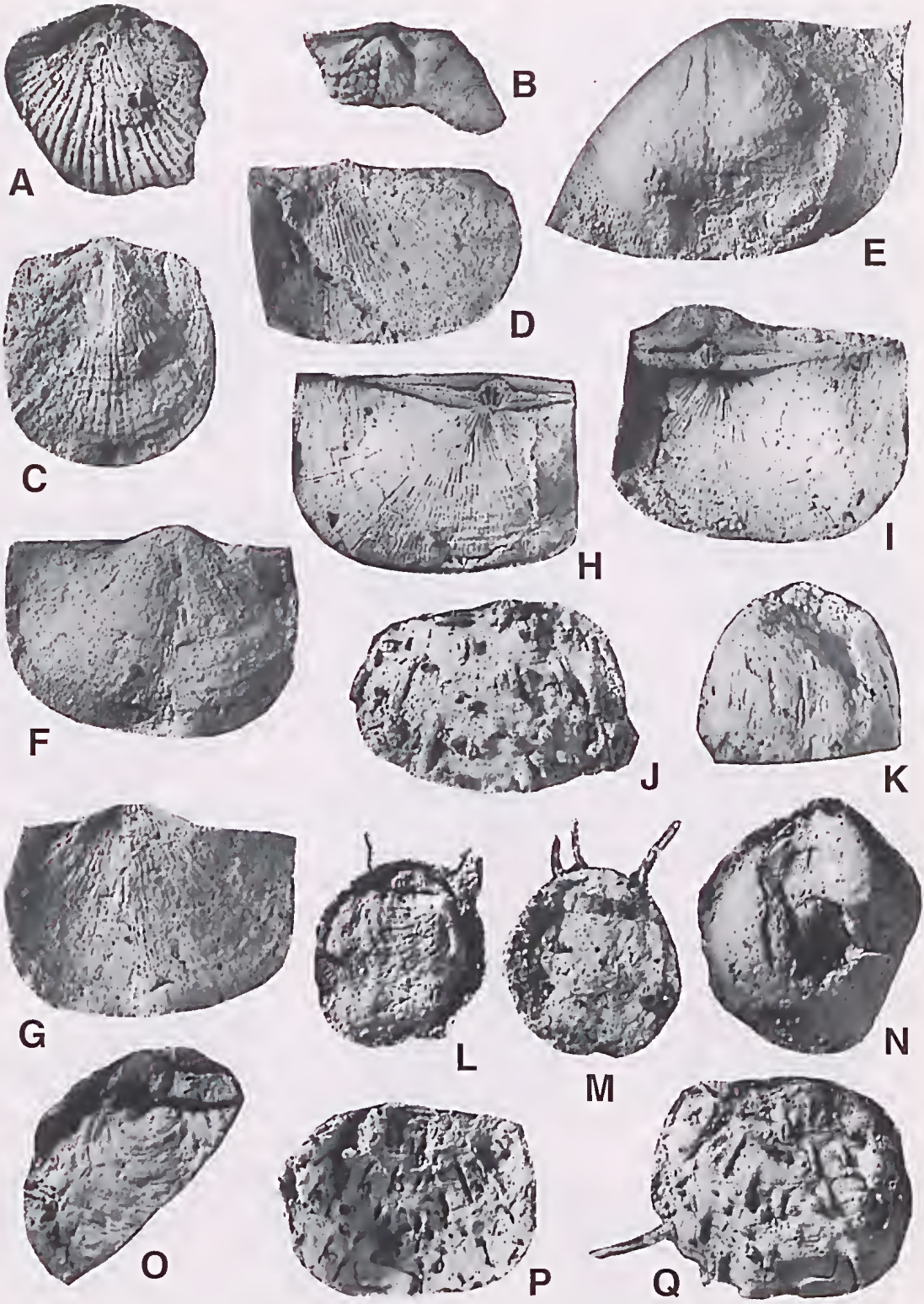
Holotype. GSWA F47189, external mould of dorsal surface of shell from the Calytrix Formation, Grant Group, Canning Basin (figured by Waterhouse, in Foster & Waterhouse 1988, p. 156, fig 8a; refigured herein fig. 5L, M).

Other figured material. Two ventral valve external moulds (GSWA F47188, F49449); two ventral valve internal moulds (GSWA F47191, F49450); incomplete dorsal external mould, of shell (GSWA F47190), all from the Calytrix Formation, Grant Group, Canning Basin.

Measurements (in mm). e = estimate.

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
GSWA F47189	4.3	5.5	6.5	5.5
GSWA F47188	–	12.4	10.5+	–
GSWA F49449	–	12.5	10.0+	–
GSWA F47191	–	9.8e	11.1	–
GSWA F49450	–	10.1	9.5+	–
GSWA F47190	6.2e	8.0e	–	–

Fig 5. All specimens from Calytrix Formation, Grant Group. A, B, *?Streptorhynchus* sp. A, GSWA F49444, dorsal valve external mould, ×3.2. B, GSWA F49445, dorsal valve internal mould, ×1.2. C, *Arctitreta* sp. GSWA F49446, dorsal valve, external view, ×2.4. D–I, *Neochonetes (Sommeriella) obrieni* sp. nov. D, GSWA F49447, external mould of ventral valve, ×3.2. E, GSWA F49448, decorticated ventral valve, ventral view, ×2.5. F, G, GSWA 47187, ventral valve exterior and external mould of same valve, ×3.5. H, I, GSWA F47186, external mould of dorsal shell surface and latex cast of surface, ×3.5. J–Q, *Etherilosia calytrixi* sp. nov. J, GSWA F49449, latex cast of ventral exterior, ×3.2. K, GSWA F49450, ventral valve internal mould, ×3. L, M, holotype, GSWA F47189, external mould of dorsal shell surface and latex cast of surface, ×4.5. N, GSWA F47191, internal mould of ventral valve, ×3.2. O, GSWA F47190, incomplete dorsal external mould, ×4.2. P, Q, GSWA F47188, external mould of ventral valve and latex cast of valve, ×3.2.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Description. Shell small for genus, circular to weakly transverse in outline. Hinge extremities weakly pointed, ears poorly developed. Ventral valve moderately to strongly convex, dorsal valve relatively flat. No ventral sulcus or dorsal fold. Maximum width close to mid-length. Cicatrix poorly known but apparently of moderate size judging from rhizoid spine impressions on GSWA F47189. Ventral valve spinose with spines of rhizoid type near umbo and sub-erect type over valve remainder. Body spines from 0.4 mm to 0.7 mm in diameter, 1.2 mm to 2 mm between spines. Spines arranged in poorly defined rows.

Interareas distinct, flat, relatively low, dorsal interarea at right angles to commissure on GSWA F47190. Pseudodeltidium distinct, narrow.

Dorsal spines absent, growth increments and traces of radial capillae weakly developed, the latter only anteriorly on GSWA F47190. Nepionic part of dorsal valve 2.2 mm wide and convex. Dorsal interior unknown.

Ventral interior with adductor scars on low, raised platform, diductor indistinct, rounded. Valve interior pustulose with anterior and lateral spines opening into valve.

Discussion. Considerable debate has surrounded the identity of these small specimens as indicated by the synonymy above. Most comparisons have been with much larger species of *Strophalosia* such as the Tasmanian species *Strophalosia concentrica* or *Strophalosia subcircularis*, both fully described and illustrated by Clarke (1970a, 1990, 1992), or the Western Australian species *Strophalosia irwinensis* Coleman (1957) as described by Archbold (1986). A re-examination of available material and the use of latex casts has revealed that the species is assignable to *Etherilosia* on the basis of its small size, moderate ventral convexity and ventral spine pattern including rhizoid spines not documented in the original description.

Etherilosia calytrixi sp. nov. is distinguished from *Etherilosia carolynae* sp. nov. by its smaller size, lack of prominent capillae and more strongly developed ventral convexity. *Etherilosia etheridgei* (Prendergast 1943), see Archbold (1986, fig. 3A–Z, AA–BB), is usually a small species with widely scattered ventral spines and a distinctly concave dorsal valve.

Suborder PRODUCTIDINA Waagen, 1883

Superfamily AULOSTEGOIDEA Muir-Wood & Cooper, 1960

Family AULOSTEGIDAE Muir-Wood & Cooper, 1960

Subfamily AULOSTEGINAE Muir-Wood & Cooper, 1960

Genus **Taeniothaerus** Whitehouse, 1928

Type species. *Productus subquadratus* Morris, 1845.

Taeniothaerus sp.

Fig. 8A, C

Comments. Two incomplete specimens of ventral valves (a natural cast and an external mould – GSWA F49462, F49463) provide the first record of *Taeniothaerus* from the Lyons Group of the Carnarvon Basin. The specimens from near Snake Well, Eudamullah Station, show the characteristic ventral spine pattern of the genus. Spine bases are of variable length on GSWA F49462, being 5 to 8 mm in length and spaced at 2.5 mm at the anterior of the specimen. The coarseness of the spine bases is unlike the much finer ventral spine bases of other Early Permian species of *Taeniothaerus* from Western Australia (Archbold et al. 1993). However, *Taeniothaerus aifamensis* Archbold (1991b, fig. 3F–I) from the Sterlitmakian (or perhaps Tastubian) of Irian Jaya possesses spines bases of comparable size although more tightly arranged. Eastern Australian Artinskian species of *Taeniothaerus* (see Parfrey 1983; Parfrey 1989; Briggs, in Waterhouse 1986b) are also characterised by relatively coarse ventral spines.

Superfamily PRODUCTOIDEA Gray, 1840

Family DICTYOCLOSTIDAE Stehi, 1954

Genus **Callytharrella** Archbold, 1985

Type species. *Dictyoclostus callytharrensis* Pendergast, 1943.

Callytharrella sp.

Fig. 8D

Comments. A single, incomplete, external mould of a dorsal valve (GSWA F49464) from near Snake Well, Eudamullah Station, Carnarvon Basin, is the first verified record of a reticulate productid from the Lyons Group. The specimen (estimated width = 30 mm, estimated height = 18 mm) is referred to *Callytharrella* and indicates a smaller species than *C. callytharrensis* (Prendergast) with significant geniculation of the dorsal valve at 16 mm from the umbo. Costae and rugae are comparable with those of *C. callytharrensis* but the dorsal fold is very weakly developed.

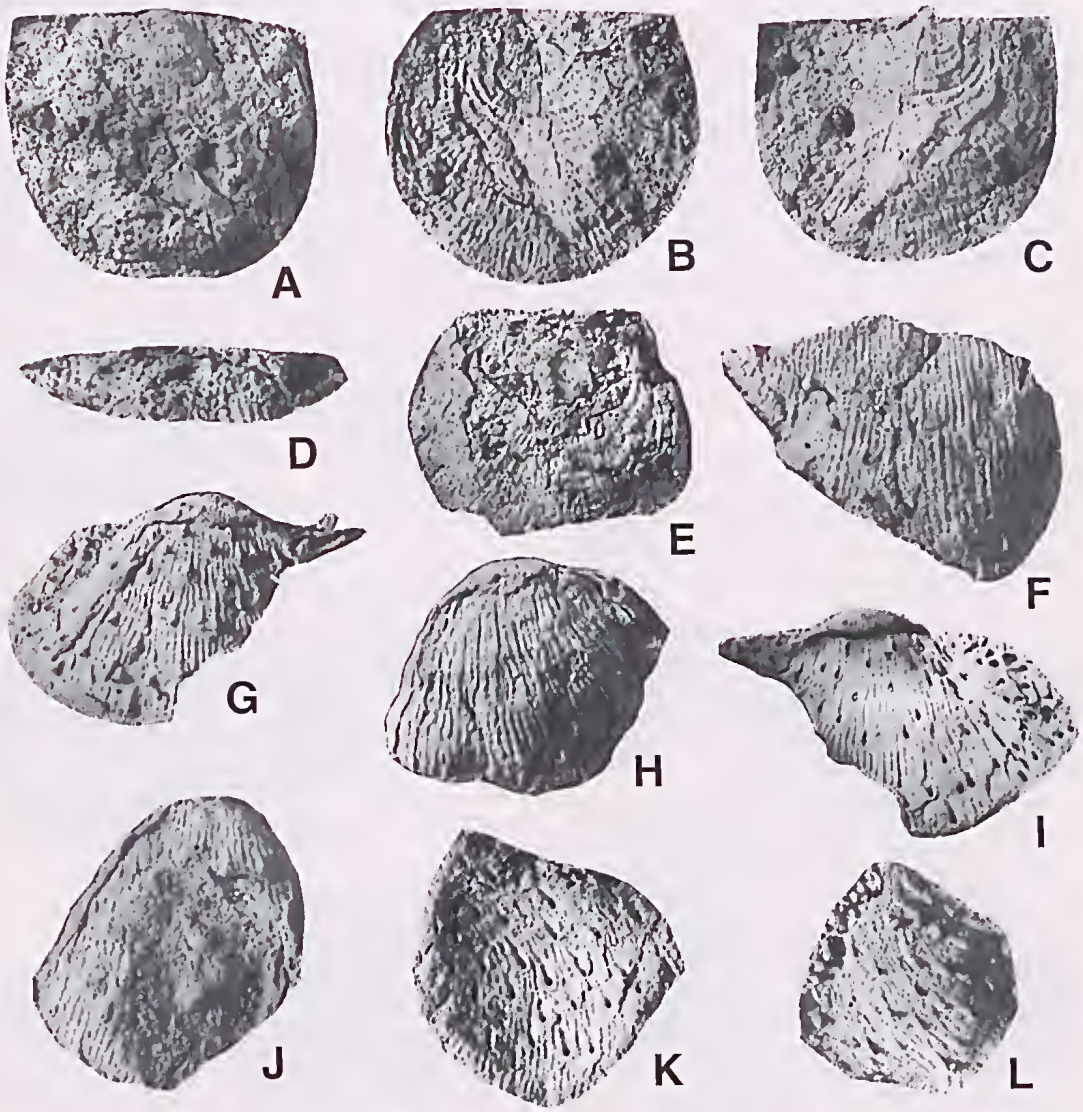


Fig. 6. All specimens from Calytrix Formation, Grant Group. A–L, *Costatumulus capillatus* (Waterhouse, 1988). A, D, GSWA F47194, dorsal valve external mould, full and anterior views, ×3. B, C, GSWA F47196, dorsal interior mould and latex cast of dorsal interior, ×3. E, GSWA F49451, dorsal valve external mould, ×3. F, GSWA F49452, latex cast from incomplete ventral valve external mould, ×3.5. G, I, GSWA F47195, latex cast and ventral valve external mould, ×3. H, GSWA F47192, internal mould of ventral valve, counterpart of GSWA F47195, ×3. J, GSWA F49453, latex cast of ventral valve external mould, ×3. K, L, GSWA F47193, holotype, incomplete ventral valve external mould, ×3, and latex cast, ×2.5.

Superfamily LINOPRODUCTOIDEA Stehli, 1954

Family LINOPRODUCTIDAE Stehli, 1954

Subfamily AURICULISPININAE Waterhouse, 1986b

Genus **Costatumulus** Waterhouse, 1983a

Type species. *Auriculispina tumida* Waterhouse, in Waterhouse et al. 1983.

Costatumulus capillatus (Waterhouse, 1988)

Fig. 6A–L

Terrakea capillata Waterhouse (in Foster & Waterhouse 1988), 156, fig. 8d–h.
Costatumulus capillata—Archbold 1993a, 315.

Holotype. A fragment of a ventral valve external mould (GSWA F47193) from the Calytrix Formation, Grant Group, Canning Basin (figured by Waterhouse, in Foster and Waterhouse 1988, p. 156, fig. 8e; refigured herein Fig. 6K, L).

Other figured material. Two dorsal valve external moulds (GSWA F47194, F49451); a dorsal valve internal mould (GSWA F47196); three incomplete ventral valve external moulds (GSWA F47195, F49452, F49453); a ventral valve internal mould (GSWA F47192) which is the internal mould of GSWA F47195).

Comments. This species was described in some detail by Waterhouse (in Foster and Waterhouse 1988) but the use of latex casts and additional specimens, as illustrated herein, permit the revision of morphological details and a reassessment of the generic position of the species. Ventral spines arise from spine bases of variable length which in turn arise from thickening of individual costellae. Preservation shows that ventral spines are hollow with delicate tubes of sediment being preserved on external moulds. Dorsal spines reported on the anterior of specimen GSWA F47194 by Waterhouse are not spines because the few small holes on the anterior margin of the external mould lack any central infilling sediment tubes which are to be expected from this type of preservation of productid spines. Furthermore the position of the holes would indicate that such spines arose between costellae rather than from them, again unlikely for a productoid brachiopod. Numerous fine hair like broken pieces of bryozoans are preserved with the dorsal external mould, GSWA F47194, are of various angles to the shell surface and the features previously interpreted as spine bases appear to be fragments of these. A second dorsal valve external mould, GSWA F49451, possesses no trace of dorsal spines.

Additional specimens of ventral valve external moulds indicate that ventral spines are less numerous on the anterior trails of mature specimens.

This species is notable for its small size. Morphological features indicate that it is better assigned to *Costatumulus* but its small size is highly distinctive within the genus. *Terrakea* Booker (1930) is not yet reliably known from the Western Australian Permian (cf. Archbold 1993b).

Costatumulus sp.

Fig. 4J

Comments. A single specimen (CPC 33521) of a small dorsal valve from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group indicates the presence of *Costatumulus* or a related genus. The specimen (7.8 mm wide, 6.5 mm length) lacks spines but possesses fine radial costellae and concentric rugae. Material is inadequate for comparison with other, larger, Western Australian species of the genus (Archbold 1993b).

Order SPIRIFERIDA Waagen, 1883

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily SYRINGOTHYRIDOIDEA Frederiks, 1926

Family SYRINGOTHYRIDIDAE Frederiks, 1926

Subfamily PERMOSYRINXINAE Waterhouse, 1986

Genus **Cyrtella** Frederiks, 1924

Type species. *Cyrtia kulikiana* Frederiks, 1916.

?Cyrtella sp.

Fig. 7A

Comments. A single specimen (GSWA F49454, estimated width 45 mm) of a ventral valve internal mould with a distinctive pointed muscle field, possible traces of puntae and divergent adminicula may represent a juvenile cyrtellid. It is figured for completeness of illustrating the fauna from the Calytrix Formation but is inadequate for comparison with other Western Australian cyrtellids.

Superfamily SPIRIFEROIDEA King, 1846

Family TRIGONOTRETIDAE Schuchert, 1893

Subfamily TRIGONOTRETINAE Schuchert, 1893

Genus **Trigonotreta** Koenig, 1825

Type species. *Trigonotreta stokesii* Koenig, 1825.

Trigonotreta spp.

Figs 4K, L, 7B–F

Figured material. Two incomplete ventral valves (CPC 33522–33523) from east of the Carolyn Bore, Wye Worry Member, Carolyn Formation, Grant Group, Canning Basin. Two dorsal valve internal moulds (GSWA F49457–F49456), one ventral valve internal mould (GSWA F49455) and one ventral valve external mould (GSWA F49458) from the Calytrix Formation, Grant Group.

Measurements (in mm). e = estimate.

Specimen	Hinge width	Maximum width	Ventral height	Dorsal height
CPC 33523	–	30.0e	–	–
GSWA F49457	15.0	18.0	–	9.5
GSWA F49456	–	24.0e	–	13.0+
GSWA F49455	35.0e	38.0e	17.0+	–
GSWA F49458	33.0	33.0	15.0+	–

Comments. These specimens indicate the presence of *Trigonotreta* within the Tastubian faunas of the Canning Basin. Characteristic coarse primary costae with secondary bifurcations resulting in fascicles of three costae are developed on the larger specimens. While the specimens are inadequate for precise comparison with described early Permian *Trigonotreta* species from Western and eastern Australia (Archbold & Thomas 1986; Archbold 1991a; Clarke 1990), they add to the Gondwanan record of the genus.

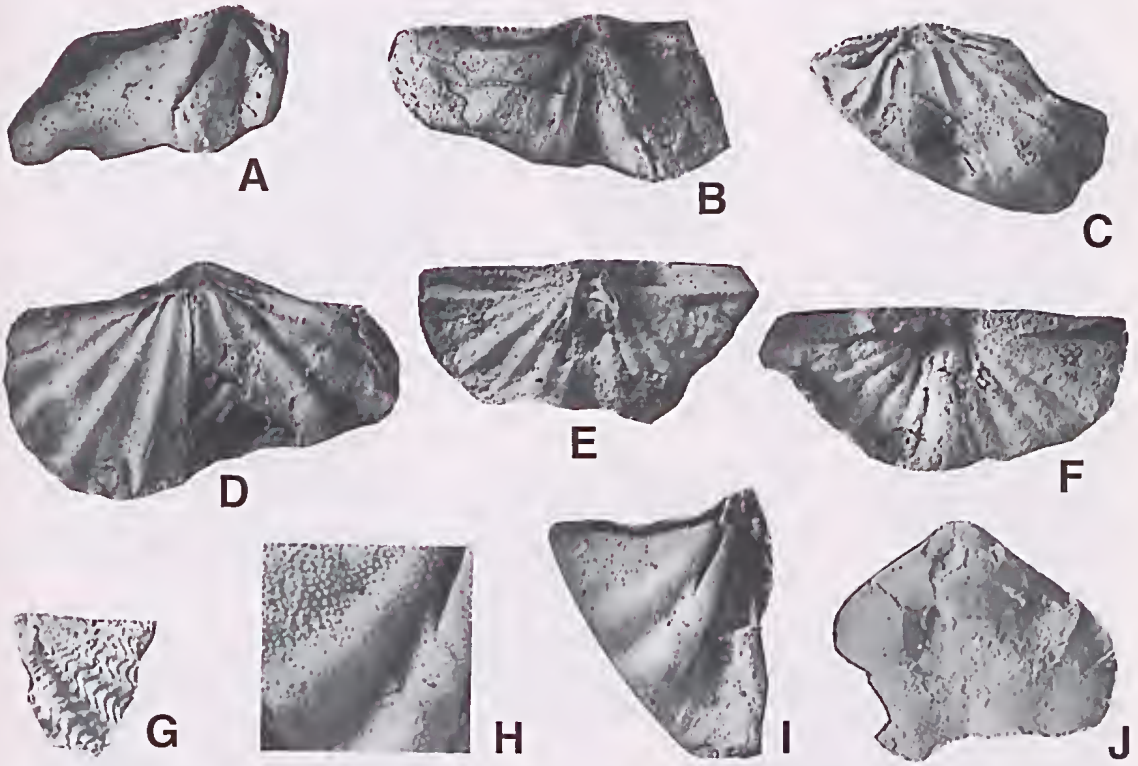


Fig. 7. All specimens from Calytrix Formation, Grant Group. A, GSWA F49454, *?Cyrtella* sp., ventral valve internal mould, ×1.5. B–F, *Trigonotreta* spp. B, GSWA F49455, ventral valve internal mould, ×1.4. C, GSWA F49456, dorsal valve internal mould, ×1.8. D, GSWA F49457, dorsal valve internal mould, ×2.5. E, F, GSWA F49458, latex cast of ventral exterior and ventral valve external mould, ×1.2. G–I, *Spiriferellina* sp. G, GSWA F49459, latex cast of incomplete ventral valve external mould, ×3. H, I, GSWA F49460, detail of ventral internal mould and internal mould, ×6 and ×2.6. J, *?Martinia* sp. GSWA F49461, ventral valve in ventral view, ×2.6.

Subfamily SPIRIFERELLINAE Waterhouse, 1968

Genus **Spirifcrella** Tschernyschew, 1902

Type species. *Spirifer suranae* de Verneuil, in Murchison et al. 1845.

Spirifcrella sp.

Fig. 8E

Comments. A single incomplete internal mould of a dorsal valve (GSWA F49465) from the Lyons Group near Snake Well, Eudamullah Station, Carnarvon Basin, possesses the characteristic coarse costae and elongated outline of a spiriferellinid. The valve is distinct from the Sterlitamakian *Elivina hoskingae* Archbold & Thomas (1985a), the dorsal valve of which possesses fine costae that bifurcate early in ontogeny. This specimen is the oldest record of a spiriferellinid from the Western Australian Permian.

Superfamily MARTINIOIDEA Waagen, 1883

Family MARTINIIDAE Waagen, 1883

Subfamily MARTINIINAE Waagen, 1883

Genus **Martinia** McCoy, 1844

Type species. *Spirifer glaber* Sowerby, 1820.

?Martinia sp.

Fig. 7J

Comments. A single, finely pustulose ventral valve (GSWA F49461), width 12 mm, length 10 mm, probably indicates the presence of *Martinia*, or an allied genus, in the fauna of the Calytrix Formation. Martiniids are not otherwise recorded from the Western Australian Permian (Thomas 1969)—rather surprisingly given their cosmopolitan distribution during the early Permian.

Order SPIRIFERINIDA Ivanova 1972

Family CRENISPIRIFERIDAE Cooper & Grant 1976a

Genus **Spiriferellina** Frederiks 1924

Type species. *Terebratulites cristatus* von Schlotheim 1816.

Spirifcrellina sp.

Fig. 7G–I

Comments. An incomplete, thickly punctate ventral valve internal mould (GSWA F49460) and an incomplete, strongly lamellose, external mould of a ventral valve (GSWA F49459) from the Calytrix Formation, Grant Group, add to the minor record of spiriferinids from the Western Australian Permian (Archbold et al. 1993). The specimens are figured for completeness of the fauna and are tentatively referred to *Spiriferellina* Frederiks (1924).

Order RHYNCHONELLIDA Kühn 1949

Superfamily RHYNCHOPOROIDEA Muir-Wood 1955

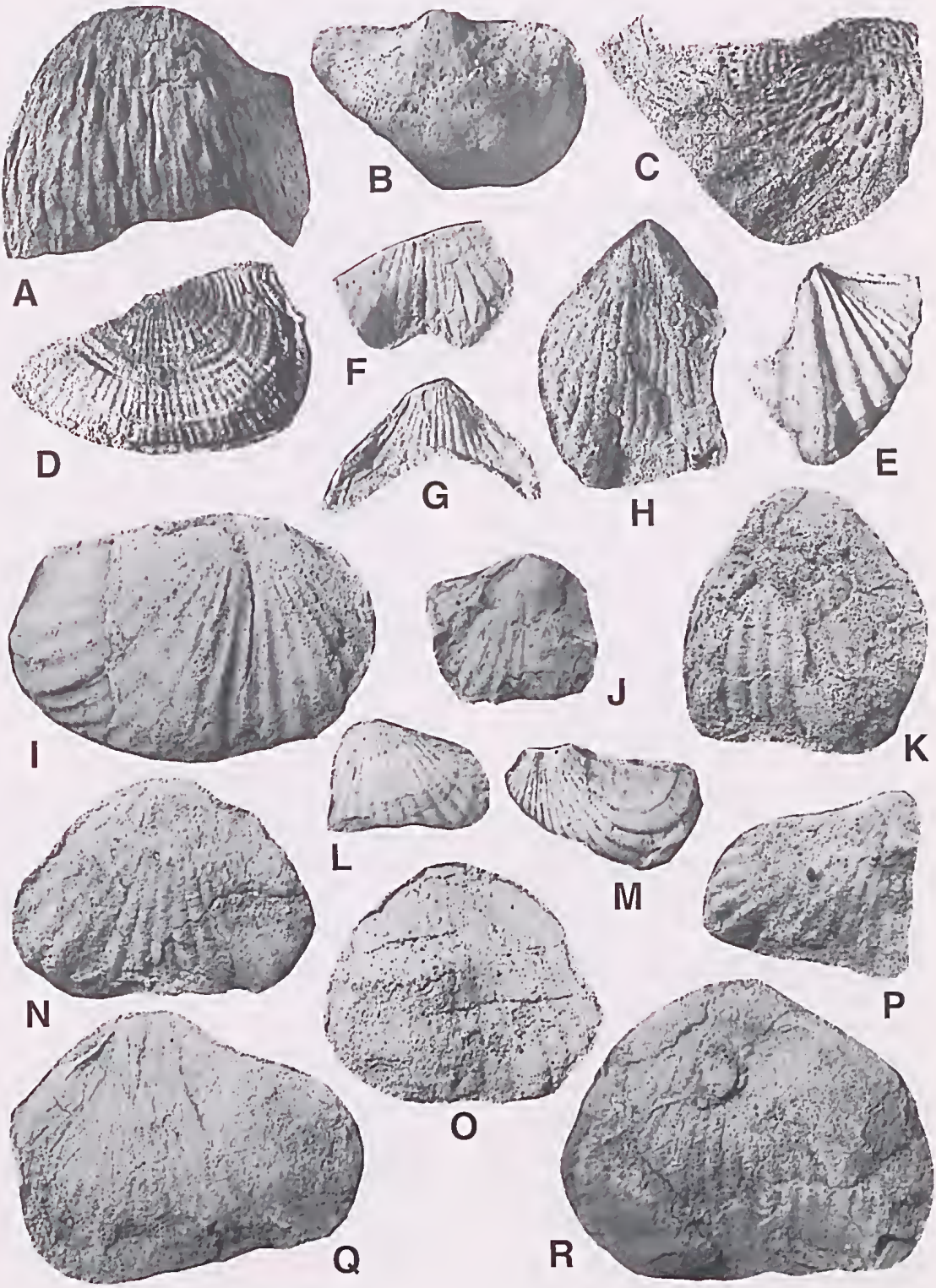
Family RHYNCHOPORIDAE Muir-Wood 1955

Genus **Rhynchopora** King 1865

Type species. *Terebratula geinitziana* de Verneuil, in Murchison et al. 1845.

Comments. The type species of *Rhynchopora* has been comprehensively studied by Erlanger (1981)

Fig. 8. All specimens from Lyons Group, Carnarvon Basin except for B from Carrandibby Formation, Carnarvon Basin. A, C, *Taeniothaerus* sp. A, GSWA F49462, natural cast of ventral exterior, ×1.5. C, GSWA F49463, external mould of juvenile ventral valve, ×1.5. B, *Neochonetes (Sommeriella) obrieni* sp. nov., CPC 33512, decorticated ventral valve in ventral view, ×3.2. D, *Callytharrella* sp., GSWA F49464, dorsal valve external mould, ×1.5. E, *Spiriferella* sp., GSWA F49465, dorsal valve internal mould, ×1.5. F–R, *Rhynchopora australasica* sp. nov. F, CPC 33532, incomplete ventral valve, ×1.6. G, CPC 33533, incomplete ventral valve, ×1.6. H, CPC 33529, latex cast of crushed ventral valve, ×1.5. I, CPC 33530, internal mould of dorsal valve, ×2. J, CPC 33534, ventral valve, ×1.6. K, CPC 33531, crushed internal mould of shell in dorsal view, ×2. L, CPC 33536, incomplete dorsal valve, ×1.8. M, CPC 33535, incomplete ventral valve, ×1.8. N, CPC 33524, holotype, ventral valve in ventral view, ×2.2. O, CPC 33525, ventral valve in ventral view, ×2. P, CPC 33527, incomplete ventral valve, ×2. Q, CPC 33526, worn ventral valve in ventral view, ×2. R, CPC 33528, worn ventral valve in ventral view, ×2.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on the basis of topotypic material from the Kazanian Stage of Archangel Province, European Russia.

Rhynchopora australasica sp. nov.

Fig. 8F–R

Rhynchonellacea gen. ind. Dickins & Thomas 1959, 74, 77.
Rhyehonellaecan (*sic*) brachiopod Dickins 1967, 16.
Rhynchopora sp. nov. Thomas 1969, 218, 220, 228.
Rhynchopora Archbold et al. 1993, 45.
Rhynchopora sp. Archbold 1993a, 314.

Holotype. CPC 33524, a worn ventral valve from AGSO locality ML6, lowest known marine horizon of Lyons Group, 5.6 km west of north of Moogooree Homestead, Carnarvon Basin.

Other figured material. CPC 33525–33528, four ventral valves; CPC 33529 an external mould of a ventral valve; CPC 33530, an internal mould of a dorsal valve and CPC 33531, a distorted internal mould of a shell, all from AGSO locality ML6. CPC 33532–33535, four incomplete ventral valves and CPC 33536, an incomplete dorsal valve from Core 32 of the Mount Madeline (BMR 8) well, Lyons Group (depth in well 912.5–915.5 metres).

Measurements (in mm). e = estimate.

Specimen	Maximum width	Ventral height	Dorsal height
CPC 33524	21.0	16.0	–
CPC 33525	22.0+	18.5	–
CPC 33526	27.5	22.0	–
CPC 33528	27.0	22.5	–
CPC 33530	26.0+	–	19.0+

Description. Large size for genus, subtriangular to rounded in outline. Ventral umbo with foramen. Maximum width at anterior of mid-length. Ventral sulcus arises 6 to 8 mm from ventral umbo, widens at wide angle (45–50°). Ventral costae arise at umbo, 5 to 6 pairs in sulcus, 4 to 6 pairs on lateral flanks. Costae initially fine and sharply rounded, by anterior of larger valves costae somewhat flattened with narrow interspaces. Costae up to 2 mm wide at anterior of valve.

Dorsal valve with 4 to 5 costae on each flank of fold with up to 6 costae on each lateral flank. Fold flattens at anterior of large specimens.

Punctae coarse—up to 8 or 10 per 2 mm anteriorly.

Ventral dental plates distinct, diverge at 25–30°. Dorsal median septum distinct. Other internal structures unknown.

Discussion. This distinctive, large species is moderately close to *Rhynchopora culta* Waterhouse (1982b) from the Tastubian faunas of Peninsular Thailand, which is a smaller species usually with a more trigonal outline and more inflated shell. Puntae are finer in the Thai species than *R. australasica* sp. nov.

R. culta reported from the Sterlitamakian of western Malaysia (see Shi & Waterhouse 1991, fig. 3—3,4) is a strongly inflated shell with coarser costae than those of *R. australasica* sp. nov.

Thomas (1969, p. 228) compared the new species with *R. lobjaensis* (sic) Tolmachev as figured by Likharev, (1934a) and Ustritsky & Chernyak (1963). Tolmachev's species *R. lobiensis* (see Tolmachev 1912, pl. 4, fig. 6; Tolmatschow 1915, pl. 4, fig. 6), has usually been misspelt as *lobjaensis* by subsequent authors (Likharev 1934a; Zavodovsky & Stepanov 1971; Abramov & Grigoryeva 1988) except for Likharev (1932) and Erlanger (1981). *R. lobiensis* is a large species from the Late Permian of the Kolyma–Omolan region of north-eastern Siberia, the Verkhoyansk Mountains and the Taimyr Peninsular (see Likharev 1934a, pl. 9, figs 12–24; Zavodovsky & Stepanov 1971, pl. 67, figs 7–10; Abramov & Grigoryeva 1988, pl. 16, figs 4, 6–9; Ustritsky & Chernyak 1963, pl. 27, figs 1–6). It is morphologically close to *R. australasica* sp. nov. in terms of size and outline but possesses widely divergent dental plates and a narrower ventral sulcus.

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